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SCIENCE AND THE MILITARY

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I. INTRODUCTION

The discussion of this paper will be based on the following set of propositions on the relationship between science and technology:

1. Science has become a principal innovative force for the development of new technology; this recent and central role of science will almost surely continue.
2. The innovative role of science for military technology became particularly evident during World War II and has continued at an accelerated pace during the post-war years.
3. There is increasing concern among the developed nations of the world about the social impacts of technology, arising especially from the rapid rate of social change brought about by science-based technology.
4. These trends are particularly troublesome in the case of military technology, partly because of

the special characteristics of military activities and the inadequacy of control mechanisms for them, and partly because of the comparatively low social benefits which come from modern military technology, compounded by the diversionary effect of allocating large expenditures for military research and development.

5. Basic scientific research has been increasingly supported by the world's programs of military and space R&D; this raises the twin dangers of a "captive science," beholden to the military and, alternatively, of the development of an unduly influential scientific-technological elite.

These propositions, if accepted, strongly suggest the need for far better analyses of the application of science and technology to military affairs and also suggest that scientists must give particular and personal attention to this problem area. But before considering implications, it will be useful to reflect further on the propositions themselves.

II. REFLECTIONS ON THE PROPOSITIONS

1. Science as a generator of technology. Both science and technology have been with mankind for a very long time; science since the time of the Greeks and technology for many millennia more. Not until the last few hundred years, however, has science played a major significant contributing role in the development of technology. Indeed, it can be argued that in the early days of science, the direction of influence was rather from technology toward science. As scientific information accumulated and as the study of science was systematized and extended, a gradual shift began to occur, ultimately leading to the great utilization of science for the development of technology which we now experience. A distinguished science historian put it this way:[4]

> ...it is difficult to think of any scientific discovery made before the nineteenth century which radically altered man's diet, his health, his means of production, his transportation and communication, or even his methods of warfare. Today we are aware that the applications of new discoveries about the nature of the universe will be tomorrow the source of a new fabric, a new military weapon for offense or defense, a new means of controlling or preventing disease, or of founding an industry. Every major corporation in the United States now supports great research establishments; and the constant stream of new products and devices emphasizes the fecundating power of abstract science and its applications in

altering the world. Yet this aspect of science is a characteristic of the last one hundred years only. Not until the middle of the nineteenth century did the applications of science begin to make themselves felt. Indeed, the organized research laboratory as a part of industry is hardly half a century old. Much of our bewilderment at the world in which we live may arise from the novelty of the revolutionary century at whose end we stand, and which itself was altered at its midpoint, about fifty years ago.*

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* A specific example may be useful here. The central research laboratory of one of the largest oil companies of the world celebrated its fiftieth birthday only in 1969. This laboratory has expanded in this half century to where it now employs roughly 2000 scientists and engineers and operates at a budget of several scores of million dollars a year.

A particularly lucid analysis of the changing relations between science and technology was recently given by H. W. Bode.[2] Bode argues that the deliberate application of science to technology on a broad scale is an even more recent phenomenon than implied above becoming important only during World War II. He lays particular stress on the very rapid development of science-based industries, as for example, the chemical industry, the electronics industry and the computer industry. As Bode notes:

The science-based industries naturally reflect, to some extent, the characteristics we have previously ascribed to modern science itself. For example, as modern science is becoming interdisciplinary, we may expect its applications to be even more interdisciplinary. Thus in many technological situations we may need substantial teams of scientists and engineers to encompass the required skills. As experimental procedures in a single science are increasingly likely to depend upon a mixture of tools and methods borrowed from other sciences, we can expect a corresponding hybridization of tools and methods in technology. The fact that science frequently takes long steps forward nowadays has its counterpart in the fact that technological projects are frequently quite ambitious.

In sum, although the deliberate application of science to technology is relatively new, it is already very firmly established, and will inescapably deepen and expand. In doing so, it will modify both the ways in which technology is developed and the specifics of the technologies themselves.

2. Science and the military. Understandably, most analyses of the increasing role of science in the military start with the development of the atom bomb in 1945. This was a remarkable event in the history of military technology in that a major new scientific discovery, nuclear fission, was developed into a revolutionary military weapon in the time-span of a single war. It can be additionally argued that the

decade from 1945 to 1955 saw the advent of not one but three genuine revolutions in military technology: the atom bomb and its follow-on, the fusion bomb; the precision guided intercontinental ballistic missile; and breakthrough developments in military communications and control. Science contributed fundamentally to the first of these and importantly to the other two, principally through the discovery of new solid-state electronic devices of which the transistor was the first. Major expenditures for science-based military technology have continued since these watershed days and the central role of new scientific information for the development of military technology is now very generally accepted. As a typical illustration, the chilling forecast of future directions of warfare entitled, Unless Peace Comes[3] carries the subtitle, "A Scientific Forecast of New Weapons," and fully half of the articles in the book relate to applications of recent science to military weapons or military strategies and tactics. We may safely conclude that scientific warfare is with us for the indefinite future. (See also Reference 5.)

3. Societal concern with science and technology. The developed nations of the world have exhibited a recent and rapid increase in concern with the impact of virtually all aspects of technology. These relate to the quality of life in general and the degradation of the environment in particular, the loss of privacy, and the fear of the impact of military

technology. As a colleague of mine put it:[6]

> Too many of these [scientific] processes have effects which, though beneficial in many respects, often strike the average man as a threat to his individual autonomy. Too often science seems to be thrusting society as a whole in directions which it does not fully understand and which it certainly has not chosen.

A similar but more extended analysis of the problem was given by Eugene Skolnikoff in a study of science, technology and foreign policy:[8]

> ... the accretion of scientific knowledge continues to put ever more power under man's control, power with the potential of acutal destruction of the human species or of alteration of the species and the environment in ways incommensurate with present values. The motivation can also be stated in more modest terms: scientific advances often lead to developments that increase the instability of power. Or, more precisely: the unpredictability of scientific advance implies that it is always a potentially destabilizing factor in international relations. The possibility of sudden developments that would make a new weapons system feasible, such as an effective missile defense or a discovery that reduces the cost and complexity of powerful weapons, thereby making them available to smaller countries, are cases in point.
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> It is a platitude to observe that it is not science itself that is destabilizing and it is not science that is the direct agent for evil. It is, instead, man's technological application of scientific

knowledge that should be the focus of attention. But the layman has the right to ask not only whether technology can be controlled but also whether the underlying science that made the technology possible can be controlled.

Widespread as these concerns are for all kinds of technology and for the role of science in generating technology, there are ample reasons why the concerns should be particularly sharp for military technology. A first point is that although military technology has an ancient and honorable history of application to civilian problems, in this recent period of science-based military technology the civilian utility of these efforts has become so much smaller that expenditures for military technology constitute very largely a diversion of funds and technical manpower from civilian efforts. In substantial measure this shift in position relates to the very great increase in the sophistication and specialized character of military technology which the application of science has itself brought about. There remains substantial controversy over the precise amount of "civilian spin-off" from military and space research and development. It is evident that there is some spin-off, as witness the civilian jet aircraft which followed from the military aircraft developments of the 1940's and 1950's. But specialization has limited such spin-off, and a generous estimate is that perhaps as much as 20 percent of military and space R&D has significant civilian utility.

A different sort of measure of the degree to which the development of military technology competes with civilian-oriented efforts is the amount of involvement of trained manpower. Some indication of the magnitude of this is the estimate that about 40 percent of the world's research and development efforts have, in recent years, gone into military R&D.**

** This very approximate estimate can be roughly justified. Military and space R&D in the U.S. is now about 43 percent of the nation's total, although for the decade from 1957 to 1967 the fraction has been greater than one-half. For the U.S.S.R., most estimates of this fraction are well above 50 percent, ranging up to one estimate from the U.S. Pentagon of 80 percent. If one lumps the U.S. and U.S.S.R. together and estimates that half their total R&D is for military and space, an estimate of 40 percent of the total for the entire world seems reasonable. (Figures for the U.S. from National Science Foundation report, "National Patterns of R&D Resources - Funds and Manpower in the United States, 1953-70." For an analysis of Soviet expenditures for military research, see SIPRI Yearbook, 1969/70, page 288.)

A crucial reason to be concerned about the role of science in the military is the open-ended character of the demands of the military for new science-based technology.

The concept "national security" turns out in normal practice to be given an almost entirely military interpretation. And the system of checks and balances which is normally employed to establish social priorities in governmental expenditure levels turns out to work particularly poorly in the case of military spending. A recent analysis by a United States Congressman, doubtless speaking from personal experience, put the difficulty in the following words:[1]

> The pressures from within the Pentagon for increased expenditures are enormous. They stem in part from traditional and still acute competition among the military services. In part, they are the natural result of increasing technologies; each new generation of weapons means greater complexity and sophistication, and the expense seems to rise by geometric rather than arithmetic progression... The existence of a new technology seems to compel a new weapons system based on that technology; some of my ablest colleagues in the Congress believe that this process is inevitable with respect to MIRV, for example, and cannot be arrested by arms-limitation agreements or in any other way.
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> To the experts in the Pentagon, the fear of what the other side may be doing is ever present. It is natural for the military man to try to achieve absolute security against any contingency that may arise, even though intellectually he may recognize that absolute security is unattainable, he is trained and paid to think this way. Thus, the military services will always and inevitably want more than they have. Their appetites are insatiable. And the industrial concerns that are ready and eager to undertake the required contracts will encourage them...

> The real trouble comes when those civilians in government who are supposed to see to it that the military's appetite is restrained are not capable of performing that function because they have come to share the military point of view.

Further difficulties arise when one attempts to obtain adequate <u>technology</u> <u>assessment</u> of military problems in circles outside of the direct supporters and proponents of the military. A serious difficulty for the lay public is the sophisticated and generally unfamiliar character of military technology. It is difficult enough to ask an intelligent layman for a thoughtful judgment on the environmental hazards of the SST; it is of almost an order of magnitude greater difficulty to get an informed lay judgment on the technical utility or cost effectiveness of a complex military system such as an antiballistic missile system.

Another difficulty results from the fact that most military technology is developed in secret. Even in comparatively "open" societies like the U.S. and Britain, this greatly increases the problem of adequate civilian assessment. Consider, for example, the military technology of most recent political concern -- multiple independently targeted warheads, MIRV. The first public reference indicating U.S. interest in this system was made by Defense Secretary McNamara in a wide-ranging Life Magazine article in late 1967. This date, however, was sufficiently far down the road of the MIRV developmental effort that a decision to deploy was only months away. Clearly the time and information required for an adequate civilian assessment of MIRV had been precluded by the blanket of secrecy which had covered its development.

What is the position of the scientist in all this? Scientists of many countries have become increasingly involved in disarmament studies, in analyses of national and international security, and in studies of the role of science in the development of military technology. At the same time, it must be noted that the number of scientists whose research is supported by the military and space establishments has grown greatly since the start of World War II in almost all of the nations of the world. It is sobering to recall the prescient words of President Eisenhower in his 1961 Farewell Address. After giving his famous warning against undue influence from the military-industrial complex, Eisenhower went on to say:

> Akin to and largely responsible for the sweeping changes in our industrial-military posture has been the technological revolution during recent decades. In this revolution research has become central; it also becomes more formalized, complex, and costly. A steadily increasing share is conducted for, by, or at the direction of the Federal Government.
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> Today the solitary inventor, tinkering in his shop, has been overshadowed by task forces of scientists in laboratories and testing fields. In the same fashion the free university, historically the fountainhead of free ideas and scientific discovery, has experienced a revolution in the conduct of research.

Partly because of the huge costs involved, a Government contract becomes virtually a substitute for intellectual curiosity. For every old blackboard there are now hundreds of new electronic computers.

The prospect of domination of the Nation's scholars by Federal employment, project allocations, and the power of money is ever present and is gravely to be regarded.

Yet, in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific and technological elite.

Faced with this kind of concern, scientists have often argued that science itself is neutral and that the only problem is to control the technology for which science merely opens the door. But in view of massive governmental support for science, this is disingenuous to say the least. If we are to be concerned with military technology and with the role of science in generating it, then we cannot fail to be concerned with the character of the support for science itself and the uses to which science is being put.

III. RESPONSES

Supposing we accept as fact that science has become a major driving force for all technology and notably so for military technology, and further that adequate assessment and control of technology is particularly difficult in the case of the military. Suppose we note further the world-wide tendency to give the phrases "national" and "international security" a military or quasi-military interpretation. What responses are indicated?

As a preliminary point, the very magnitude and gravity of the military problem puts it in a class by itself. We are concerned with an effort which leads to expenditures of $200 billion per year world-wide, expenditures which in very large measure constitute a diversion of badly needed funds away from alleviation of the major social problems which face the world. We note further that military R&D puts particularly large demands on the skilled manpower of the world, including notably the scientists and engineers. Finally, we note that all of this occurs in the face of the evident fact that the appalling destructiveness of nuclear weapons makes it evident that major wars can no longer be "won."

If we are to respond in sufficiently effective ways to counter the very considerable momentum of the military and of science-based military technology, we must operate simultaneously at several levels.

1. There must be much greater analysis, understanding and response from the citizens of the world.
2. Governmental bodies including national governments and the United Nations, must assume responsibility for more intensive analyses of national and international security and for the development of mechanisms which disseminate widely the results of these studies.
3. The world's scholars and most notably the scientists and engineers must assume a much more active role in these analyses, giving particular attention to the implications of their own studies in contributing to the military momentum.
4. International, non-governmental meetings for study and exchange of views can help overcome the sometimes xenophobic national security analyses which make international agreements so difficult to obtain.

If the general public is to play a positive role in these analyses and in the decision making processes, a critical need is for more dissemination of information about the military, about national and international security, and about the particular problems of military technology. Difficulties arising from secrecy and from the specialized character of military systems requires an effort which goes far beyond the normal news dissemination activities. A landmark in the development of major information efforts on military problems was the campaign within the United States which arose in response to the proposed deployment of an ABM system. A consequence of the steady flow of articles, letters, speeches and books was that for the first time in the United States a broad segment of the general public was fairly well informed of the problems which would accompany the deployment of this particular military system. The continuing question then is, how can one develop procedures which will insure that similar public information efforts will accompany further developments of military technology? The U.N. has an important role here; its activities of analysis and communication on military problems should be greatly expanded. So also, should the efforts of national and international peace study societies and foreign policy analysis groups. It is, for example, a real tragedy for the United States that peace studies efforts are fragmented into so many small, often barely viable, groups.

These public information efforts must be supplemented by greatly expanded scholarly efforts to understand the problems of national and international security. These studies must give much greater stress than the military and their supporters are willing to give to the fundamentally new dimensions of warfare and security which have been brought about by the advent of nuclear weapons and ICBMs. As one key question, for how long should we be content to have as a principal element of national security a reliance on nuclear deterrence, the implications of which are that in response to a military attack from an enemy country, we will respond by destroying some tens of millions of innocent civilians who dwell in our opponents' cities? What kind of world are we building if this sort of response is to be considered rational?

A principal center and focus for the efforts of study and communication should be within governments. Here in particular is the place where the concept "national security" must be examined in a much broader context than that of the military. The dominance in decision making on security problems of Defense Ministries or of Congressional Arms Services Committees must be shattered. A small but heartening sign in the United States is the development of a vigorous informal Congressional group called the Committee for Peace Through Law. How much better it would be if such committees were formally established and had the obligation to place their recommendations alongside those which come from Armed Services Committees and Committees on Foreign Affairs?

A complicating problem is the suspicion, often bordering on xenophobia, which too frequently exists between nations and which supports and encourages the one-sided "worst case" analyses which too often fuel the military arms races. The United Nations should have a role to play in minimizing these tendencies but too frequently the United Nations itself is paralyzed by the competing national pressures.

Non-governmental international meetings offer an important avenue for increased international understanding. The Pugwash meetings, for example, made it possible for there to be exchanges of views on problems of peace and war between Eastern and Western scholars at a time when almost no other openings existed. Clearly, ways must be found to greatly increase these informal efforts toward international understanding.

In all of this, science and scientists have major roles which they must assume. In the face of the appallingly expensive military efforts and with clear evidence that science is a major innovating force for military technology, it simply will not do for science and scientists to plead neutrality. Science is being diverted into the development of technologies which are broadly diversionary and appallingly destructive.

What specifically can scientists do? The first point is the development of a greater sense of social responsibility for all aspects of the application of science to technology. This involves analyses by individual scientists of the implications of their own work. It implies educational programs to give scientists and engineers a firmer understanding of potential impacts of science and technology, as well as explicit practice in participating in the kinds of interdisciplinary technology assessments which are increasingly needed. The great scientific professional societies, the Royal Society and the U.S. National Academy of Sciences, for example, have an important role here in providing both a home for such analyses and a forum for their discussion. Surely there is a place in these societies for more explicit programs of discussion of these problems, more sponsorship of study group efforts, and more provision of supporting funds for such studies.

Scientists also have a major role to play in fostering international discussions of these grave problems. Given the international character of science it is not surprising that the international Pugwash movement was started by scientists, brought together from many nations by the dreadful prospects of nuclear war. Pugwash has broadened greatly from those early days, but the role of scientists remains central in all of its programs of study and communication. But, effective as it is, Pugwash is only a single organization of mostly part-time participants. The world could use many more such efforts.

Above all, for all of these efforts, we need more scientific activists, more people sufficiently persuaded that these problems are of such priority that they must personally give significant fractions of their time to their analysis. It is almost impossible to overestimate the importance to these efforts of a Hans Bethe, a Rudolph Peirls, an Igor Tamm, a Wolfgang Panofsky. What we clearly need is a nucleation technique which permits key people like these to catalyze the development of some scores of additional similar scientific activists. I know of now better way to underscore the problem and the need than to quote from one of these scientific activists, W. K. H. Panofsky:[7]

> Our knowledge of science will indeed increase continuously: the facts of nature are there to be explored, and they will not, and should not, remain hidden. But the process of going from science to military technology involves a protracted series of planned steps, including development, test, production and deployment. This chain extends over many years, or even decades, and it is up to man to decide through his political processes to undertake such steps or not to...
>
> I see no valid excuse why we should acquiesce in the development of weapons of ever-increasing lethality. If we subscribe to the belief that technology has a life of its own and that its progress in any direction, however antisocial, cannot be impeded, then it is indeed true that man has lost control over his own destiny.

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Guernica (1937) by Pablo Picasso

Extended Loan from the artist to The Museum of Modern Art, New York City, N. Y.